BEHAVIORAL AND HEART RATE RESPONSES OF FOUR-, FIVE-, AND SIX-WEEK-OLD INFANTS TO VARYING AUDITORY STIMULI

BY

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Constance Caranasos

Dedication

To My Husband

George John Caranasos
for his encouragement,
assistance and patience

and

To My Daughter

Ellen Constance Caranasos
that she may always
place a high value on education

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TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	iv
ABSTRACT	vii
Chapter	
I. INTRODUCTION	1
II. REVIEW OF THE LITERATURE	7
III. METHOD	23
IV. RESULTS	40
V. DISCUSSION	49
APPENDICES	56
A. SCHEMATIC OF EXPERIMENT	57
B. DATA FORMS	61
REFERENCES	71
BIOGRAPHICAL SKETCH	79

Abstract of Dissertation Presented to the Graduate Council of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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Twenty-three infants, 13 male and 10 female, ranging in ages between 4 and 6 weeks of age were exposed to three sets of four auditory stimuli. The sets were human voice, human speech, and non-human sound. The 12 stimuli were presented once in a random fashion while the infant was held by its mother, and once when not held. Behavioral responses were recorded on video tape, and an electrocardiographic record was analyzed for changes in heart rate in responses to the auditory stimuli.

There was high interobserver agreement in scoring behavioral responses from the videotape. There were no statistically significant differences in behavioral responses in the held and not held positions. Human sound stimuli produced significantly more behavioral responses than did non-human sound stimuli. Neither male nor female infants showed a preference for voices of the same or opposite sex. A significantly greater number of behavioral responses was

elicited by the auditory stimuli of an angry female than by either the non-human warble tone of 1,000 Hz from the baby beeper or by the light music.

A wide variation in heart rate occurred during all auditory stimuli and no statistically significant difference in heart rate change was determined. The preferential responses in 4-, 5-, and 6-week-old infants were found by observational data to be statistically significant for human over non-human auditory stimuli. This finding tends to lend some support to the hypothesis that human infants appear to be predisposed to language acquisition.

CHAPTER I

INTRODUCTION

Infants respond to their environment. Auditory stimuli, particularly, are received and produce early responses. The 1-day-old infant, for example, will move his eyes towards the direction of a sound (Wertheimer, 1961). More complex responses to more specific auditory stimuli occur as the infant matures (Eisenberg, Griffin, Coursin, and Hunter, 1964). Listening behavior serves as a foundation for acquiring language. Friedlander (1969) stressed the importance of the receptive functions for the development of language in children. A better understanding of the mechanisms by which these responses are produced may provide insight into how language is acquired (Eisenberg, 1967; Eimas, Siqueland, Jusczyk, and Vigorito, 1971; and Kagan, 1972).

Much recent research has centered on the perception of speech by infants (Moffitt, 1971; Morse, 1972; and Morse, 1974) and is an outgrowth of the theoretical concept that language is biologically predetermined for human beings (Lennenberg, 1967). Infants show early ability to discriminate between human and non-human sounds. Among the early sounds that infants hear are the voices and the speech patterns of the people around them. The mother's voice is

important for cognitive and affective development in infants (Turnure, 1971). Efforts have been made to determine when infants show discriminative or differential awareness of human voice and speech sounds from non-human sounds. Adults and children discriminate among various voice types (Costanzo, Markel, Costanzo, 1969; Phillis, 1970). League and Bzoch (1968, 1970) reported affective responses among infants from shortly after birth to 15 months of age to voices with varying intonation patterns, but no differential response was noted based on the sex of the infants. Aronson and Rosenbloom (1971) found that 30-day-old infants became distressed when they saw their mothers speaking to them while the sound of the voice was transmitted from another direction. The infants' ability to perceive this auditory-visual discrepancy gave strong support to the theory of early perceptive capacities.

A clear understanding of the emotional or affective responses produced by auditory stimuli dates from 1872, with the publication of Darwin's "The Expression of the Emotions in Man and Animals." Darwin stressed that there exists a natural biological continuum of expressive responses extending from animals, through human infants, to adult man. He appreciated the difficulty of the study when he noted that "although most of our expressive actions are innate or instinctive . . . it is a different question whether we have any instinctive power of recognizing them" (Darwin, p. 356).

He pointed out that animals learn to recognize ". . . the tones of voice of their masters. . . . Children, no doubt, would soon learn the movements of expression in their elders in the same manner as animals learn those of man. . . . But the question is, do our children acquire their knowledge of expression solely by experience through the power of association and reason?" (Darwin, p. 357).

Darwin further clearly indicates that infants respond differently to different stimuli: "The movements of expression in the face and body, whatever their origin may have been, are in themselves of much importance for our welfare. They serve as the first means of communication between the mother and her infant; she smiles approval, and thus encourages her child on the right path, or frowns disapproval. . . . The movements of expression give vividness and energy to our spoken words" (Darwin, p. 364). He concludes that ". . . expression in itself, or the language of the emotions, as it has sometimes been called, is certainly of importance for the welfare of mankind" (p. 366). These thoughts and their amplifications form the starting points of such disciplines as psychology, psychophysiology, and psycholinguistics (Hunt, 1961; Markel, 1969).

Darwin stressed the mother's influence on the infant's response, but just as important is the infant's influence on the mother's response: an infant's smile encourages the mother and a frown causes her to adjust her response. The

infant's response is an essential part of the communication process. While mothers have long reported with pride observations of their infant's "expressions" and their interpretations of these, these "expressions" or responses of infants were regarded as too primitive to be of any significance. Although infants have a limited and restricted repertoire of responses and expressions (Wolff, 1965; Butterfield and Siperstein, 1972), the infant nonetheless does respond to ever-present surrounding stimuli (Gray and Crowell, 1968). More importantly, newborns produce observable responses to auditory stimuli during proper states of attention (Richmond, Grossman and Lustman, 1953; Eisenberg, 1970).

An infant's startle, smile, or frown is no longer viewed as merely the result of "a gas bubble on the tummy," but is regarded as a possible emotional reaction to any number of stimuli. An accurate translation of these responses to the emotional state of the infant, however, is not possible (Crystal, 1973).

In 1921 and 1922 Piaget (1955) studied perception, language, and thought processes in children. By use of an organized and systematic biological approach to the study of the child's intellect, he established a theoretical framework that continues to affect current educational methods. Piaget provided a careful longitudinal, observational method for evaluating language development in children. The basis

of Piaget's theory was that infants from birth pass through stages of essential symbolic processing that shapes intellectual growth (Phillips, 1969).

Lennenberg, in 1967, proposed that "behavior is seen to be an integral part of the organic whole; it is related to structure and function, one being the expression of the other" (p. 3). The biological predisposition of species forms the framework of Lennenberg's theories of why only man learns to speak a language in man's uniquely characteristic way. The challenge of Lennenberg's theories led this writer to investigate the very early behavioral and physiological responses of infants to sounds of the human voice and to speech.

The study of emergent language behavior in normal infants can help provide an understanding of the development and structure of language (Bzoch and League, 1971). Regardless of the study method employed, however, results are difficult to interpret because one is dealing with the nonverbal behavior of infants.

Current interest in the acquisition and transfer of knowledge through language has focused attention on the infant as an appropriate subject for the study of emergent language. Since our society places a stigma on inadequate communication, methods of preventing communication problems have been examined. In recent years, support has become available for greater study of infants in order to better

understand human language development and in this way provide measures to help prevent communication disorders. Recent investigations have stressed (1) the study of emergent language in order to test the theory that human beings are biologically predisposed to language acquisition, (2) the development of methods to better understand how infants think and learn, (3) the assessment of the range of normal language performance, and (4) the production of methods for prevention and remediation of communication problems.

The purpose of the present study is to determine the early responses of infants to the human voice and to non-human sounds, with the aim of determining whether different types of auditory stimuli produce responses that differ in nature and degree as a result of the type of stimulus.

CHAPTER II

REVIEW OF THE LITERATURE

The newborn infant is exposed to numerous sound patterns immediately after birth. In the delivery room there is the noise of human activities and human speech, and the sounds of the infant's own crying. The voice and speech patterns of other human beings are an almost constant stimulus and an early tutor in language acquisition. It is not known how soon after birth the infant responds meaningfully or preferentially to these noises and to human speech patterns.

Many studies support the hypothesis that the normal human infant is behaviorally responsive to auditory stimuli, including human sound patterns, and demonstrates selective attentive interest in sound sources (Morse, 1974). Kussmaul, a nineteenth-century German physician, propounded the theory that the newborn is insensitive to auditory stimuli (Richmond, Grossman, and Lustman, 1953), but Forbes and Forbes (1927), and later Ray (1932), showed that even the fetus *in utero* moves in response to sound stimulation. Sontag and Wallace (1935) noted fetal movement to sound as early as the thirty-first week of gestation. Elliot and Elliot (1964) found that the middle and inner ear are fully developed by the fifth month of fetal growth. Thus, the infant, at birth,

is clearly physiologically well prepared to respond differentially to auditory stimuli (Eisenberg, 1970).

Parents have often reported with joy their infant's early apparent preferential attention to their voices in a group of speakers. A mother's report that her baby knows her voice has been viewed as eager pride or bias interfering with her objective observations. More objective approaches, however, have been made in an attempt to evaluate these early observable responses of infants to sounds and human speech. Three different scientific procedures have been most frequently applied, namely: (1) non-nutritive sucking (Eimas, Siqueland, Jusczyk, and Vigorito, 1971); (2) the use of physiologic measurements, such as measured changes in heart rate (Graham, Clifton, and Hatton, 1968); and (3) the recording of infant behavior by videotape or film to produce a permanent record that can be replayed to groups of observers as needed (League and Bzoch, 1970).

A vast recent investigational literature has developed related to speech perception, language development, expressive language, and psycholinguistics. The literature review for this presentation will emphasize the early historical literature and summarize the recent pertinent research.

Psychological Aspects

The introduction of psychological principles in the study of language dates from the turn of the twentieth century when Wilhelm Wundt established the first laboratory of

experimental psychology. From 1900 to 1909 he wrote extensively on the psychology of language (Eisenson, 1938). Psychologists moved away from the philosophy of language into the laboratory, while linguists continued to study language and its origins, generally without a psychological implication or interpretation. The awareness of Darwin's theory that language can best be understood when viewed along with human personality influenced the development of psycholinguistics. Verbal learning, human behavior, and emotions became an integral concern to psycholinguists (Markel, 1969).

Developmental psychology flourished from the 1920s to the 1950s. During this time developmental norms for infants and children were established by L. B. Ames, N. Bagley, C. Bubler, E. A. Doll, A. Gesell, E. R. Goodenough, O. C. Irwin, M. M. Shirley, and J. Piaget (Harlock, 1953). These normative data helped in the diagnosis of infant and childhood developmental disorders (Gesell and Amatruda, 1947). Normative data on phonological and morphological acquisition of speech became available during the 1930s and 1950s (Mussen, 1960). However, the stress of these studies was on expressive language phenomena, with little attention given to receptive language skills or to the field of non-verbal communication (Markel, 1969; Friedlander, 1970). As recently as 1971, Bzoch and League published a scale of emergent infant language to assess both receptive and expressive

language skills in infancy. The scale provided a means for data collection on children from birth to 3 years of age and was designed to screen for potential communication disorders (Bzoch and League, 1971).

Non-nutritive Sucking

As developmental data on language accumulated, studies utilizing measures of physiological responses to sound in infants were introduced to produce new information. As early as 1920 and 1930, studies using conditioned reflexes were undertaken in neonates. Wenger (1936) used the polygraph and photographs to record responses of infants placed in a cabinet. He used buzzer-shock-light stimuli in traditional classical conditioning experiments. Kantrow (1937) found that sucking in infants was a predictable, well-organized, and precise response that could be recorded. A nursing bottle was used, and the sucking response was recorded on a kymograph by means of a pen attached to a linen harness placed under the baby's chin. A buzzer was used to establish a conditioned reflex that would lead to sucking. By the 1950s operant conditioning had replaced classical conditioning as the preferred experimental method (Mussen, 1960).

In the Soviet Union in the 1950s, infant studies using classical conditioning techniques indicated that sucking often stopped in response to an auditory stimulus (Keen, 1964). In a study of 48 infants from 3 to 5 days of age, a pacifier was connected to a Davis cumulative recorder to

obtain a record of non-nutritive sucking patterns induced by a tone of 90 Hz (Keen, 1964). Auditory stimuli produced changes in sucking behavior, indicating that non-nutritive sucking could be used as an indicator of an infant's response to auditory signals. In another study (Sameroff, 1967), the non-nutritive sucking patterns of ten 5-day-old infants were studied in response to sound and light stimuli. Introduction of a stimulus during sucking either lengthened or shortened the expected period of sucking, while introduction of a stimulus between sucking bursts prolonged the period during which sucking was absent. These results indicated the necessity of considering the pattern of an infant's sucking response in the analysis of the effect of stimuli on sucking.

Eimas et al. (1971), using the non-nutritive sucking response paradigm, showed that 1- and 4-month-old infants can discriminate between synthetic speech sounds of the voiced /b/ and the voiceless /p/ consonants. The authors concluded that these perceptions are categorized in the manner of adult perceptions. Eilers and Minifie (1975), conducting experiments using the suckle response paradigm, found that the infants could detect differences between consonants /s/ and /v/, /s/ and /ʃ/ but not between /s/ and /z/, leading them to conclude that at times an infant may choose to ignore certain stimuli.

Voice Discrimination

Investigators of reception of auditory stimuli in infants

have been interested not only in language acquisition in the neonate but also in the detection of hearing disorders in infants (Froeschels and Beebe, 1946; Wedenberg, 1956; Fröding, 1960; Eisenberg, Griffin, Coursin and Hunter, 1964; Schulman, 1974; Thompson and Weber, 1974; Eisele and Berry, 1975). Tones of varying frequency, intensity, and duration, as well as synthetic consonant-vowel sounds, have been used as auditory stimuli for many infant-perception investigations.

In the past decade, however, attention has been given to the quality of voice and the intonation of the speaker as an important aspect of the auditory stimulus heard by the infant. Adults and children make selective discriminations among voice types and evidence affective responses to different voice qualities. A technique for rating perceptual differences in voice samplings was developed by Markel (1969, 1973). Costanzo, Markel, and Costanzo (1969) found that the type of voice heard alters the affective response produced in the listener. Voice quality is considered an important messenger of personality (Markel, 1969). Phillis (1970) found that children in the fourth to twelfth grades discriminated among voice qualities.

Using adult subjects, Gaviria (1967) measured electrodermal, plethysmographic, and heart rate changes caused by responses to four auditory stimuli: noise, the subject's own voice, the voice of the subject's spouse, and an unknown person's voice. Habituation to noise was slowest, next,

to one's own voice, then to the spouse's voice, and fastest to unfamiliar voices.

Turnure (1971) studied babies of 3, 6, and 9 months of age who heard their mother's normal voice, her voice slightly distorted, and her voice grossly distorted. An observer recorded the baby's frowns, smiles, crying, vocalizing, mouthing, and limb-mouth contact. It was found that the older infants diminished their ongoing motor activity when listening to their mother's voice as opposed to that of an unfamiliar woman.

Friedlander (1968, 1969 and 1970) used operant conditioning to study the responses of infants to voice and message patterns. He transported the laboratory to the infant's home by using an automated home measurement program. Babies from 11 to 15 months of age were presented with music, vocabulary, and message patterns from "an automated two-channel audiovisual feedback toy." The baby learned to operate the knobs of the "toy" and selectively attend to the sound stimulation of his preference. Friedlander's studies, which revealed developmental differences in an infant's preference to familiar over non-familiar or distorted voice stimuli, stressed the importance of listening on the part of the infant to voices and speech patterns in the environment in the total process of language acquisition.

Heart Rate

Heart rate response has been used for several decades as a means of measuring physiologic responses to varying stimuli. Changes in heart rate in adults, and more recently in infants, have been examined during their responses to visual, auditory, and tactile stimulation (Lipton, Steinschneider, and Richmond, 1965). A number of investigators, by use of electrocardiography, have attempted to study perceptual and cognitive abilities in young infants. Moffitt (1971) indicates that studies utilizing heart rate responses have been mainly concentrated in three areas: forms of cardiac response as a function of age, as a function of stimulation conditions, and the effects of repeated stimulation on response decrement or habituation. Ziegler (1951) reviewed the literature on electrocardiography in infants and children and concluded that there is a considerable variation in normal heart rate in infancy. The heart rate may exceed 200 beats per minute or be below 50 beats per minute in a given normal infant. He explained that heart rate alone does not indicate an abnormal cardiac mechanism. A complete diagnostic electrocardiogram is essential for this type of determination. Cassels and Ziegler (1966) confirmed these findings and pointed out that the heart rate normally is not consistently below 100 beats per minute until the child has nearly reached school age.

Heart rate response measured by current electrocardiographic computer instrumentation has decreased the time required to read an electrocardiogram. Graham, Clifton, and Hatton (1968) studied the heart rate response of newborns to a "moderately intense sound," and reported an acceleration of heart rate to the stimulus, with the heart rate later returning to pre-stimulus levels. Habituation of response, which occurs in adults, was not readily observable in these newborns. An interval of 90 seconds between stimuli again was considered too long because of loss of attention by the newborns. It was suggested that the nature of the auditory stimulus used may not produce sufficient interest on the part of the infant.

Lipton et al. (1965a, b), after careful observation of newborns, reported that physiological events have varying effects on heart rate. Activities such as crying, sucking, and movement accelerate the cardiac rate. Hiccuping may reduce the rate for one or two cardiac cycles. Furthermore, infants between 2 and 5 months of age manifested a degree of sinus arrhythmia that was the equal to, or greater than, that in newborn infants, even though the heart rate was more rapid by 2 months of age. Cardiac deceleration was observed in young infants when objects were presented to their visual field. Steinschneider, Lipton, and Richmond (1966) showed that neonates can respond differentially to graded sound intensities of white noise with changes in heart rate. With

increase in sound intensity, infants exhibited increased motor activity and an increased heart rate. Infants respond to a sound source by eye motion, head turning, and turning of the body toward the sound source (Steinschneider et al. 1966). Lipton et al. (1965, p. 152) cautioned that

> . . . although the results in human infants are strongly suggestive of fundamental maturational changes, they must be viewed with reservation. It is possible that although an objectively standard stimulus is employed, the resulting afferent discharge varies with age. Consequently, the response being examined may reflect sensory changes with age rather than autonomic-nervous system development.

Clifton and Meyers (1969) studied the heart rate response to auditory stimuli in newborns and 4-month-old infants. Newborns responded with cardiac acceleration while the older infants showed deceleration to a 10-second tone stimulus. The authors suggested that deceleration of the heart rate in the 4-month-old was related to the phenomenon "the orienting reflex," described by Sokolov in 1960 and 1963.

It has been theorized that two cardiac arousal systems exist: the defense reflex (DR) and the orienting reflex (OR). The orienting reflex (heart rate deceleration) has been demonstrated in adults. It is thought that the OR has an important influence on the psychological process of perception and learning (Uno and Grings, 1965; Germana, J., 1968; Jeffrey, W. E., 1968; Germana and Klein, 1968). There has therefore been considerable interest in determining whether

the OR is present in infants (Graham and Clifton, 1966; Graham, Clifton, and Hatton, 1968; Berg, W. K., 1974). Currently, the above cited investigators question the existence of the cardiac orienting reflex in infants below the age of 4 months. Graham and Jackson (in press) emphasized that complex or patterned stimuli rarely have been used in newborn heart rate studies. It has been recommended that more interesting patterns of stimuli be used in future research and that the behavioral state of the infant be given more consideration.

Bridger (1961) used changes in heart rate as a means of determining habituation and sensory discriminatory responses in infants 1 to 5 days of age. These infants were able to habituate and show sensory discrimination among pure tones of varying loudness. The babies differed from one another in their sensory thresholds. The heart rate increased when the infants were startled but remained the same when no behavioral change was detected.

Segall (1972) postulated that hospitalized premature infants live in a monotonous environment and do not receive the same stimulation as infants at home. An experimental group of 30 infants were presented with a tape recording of their mother's voice played for 30 minutes each day. A control group of 30 infants was not exposed to such a stimulus. The heart rate of the experimental group, as opposed to that of the control group, increased not only in response to the

mother's voice, but also to white noise, word stimulus, and an unfamiliar voice. The control group showed a less marked response to all these stimuli. It was concluded that auditory stimulation is beneficial to infants.

When simple auditory stimuli (pure tones of the same loudness) were presented to adult males, acceleration of the heart rate occurred with the onset of the stimulus but was then followed by a period of marked deceleration (Lang and Hnatiow, 1962; Geer, 1964). Bartoshuk (1962), using a clicking sound as a stimulus, found that infants from 1 to 4 days old responded with an increase in heart rate. With repeated stimulation a decrease in the magnitude of response occurred. It is not possible to determine whether acceleration of the heart rate in response to sound is a specific response to auditory stimuli or simply a general response to any new stimulus. Furthermore, the length of a heart rate response cycle to a given stimulus in early infancy is unknown.

The status of the infant at the time of electrocardiographic recording is important. Lewis, Dodd, and Harwitz (1969) found statistically significant differences in heart rate response to tactile stimulation when infants were awake, asleep, alert, fussy, drowsy, or crying. Moffitt (1971), by the use of heart rate measurements, showed that 5-month-old infants can make discriminative responses to the synthetic speech syllables "bah" and "gah." He considered

these findings in agreement with those of Eimas et al. (1971), who studied 1-month-old and 4-month-old infants by use of the non-nutritive sucking response to measure discrimination between "pah" and "bah" synthetic speech samples. These studies support the theory that language has innate properties, and imply that infants have the capacity for phonological discrimination since they can recognize some sound units but cannot coordinate the performance and production of these sounds.

Although measurements of heart rate response may not be as valid as standard audiometric procedures for measuring hearing acuity, such measures have been used not only for research but also as tests of hearing (Schulman, 1974) in order to gather information on non-verbal subjects. Richmond et al. (1953), Zeaman and Wegner (1956), and Schulman (1974) showed that changes in the heart rate could be used as a means of testing hearing.

Behavioral Observations

The coupling of behavioral observations and electrocardiographic measurements can provide additional information verifying whether an infant responds to a given auditory signal. Behavioral observations have been used to provide evidence for clinical judgments of the responsiveness of others to a sound pattern. Investigators stress the importance of observing infant responses to auditory stimuli. Lamper and Eisdorfer (1971) studied 40 newborns at 8 to 72

hours of age on three consecutive days to determine neonate response to various stimuli. Four stimuli were used: (1) 3,000 Hz at 90 dB; (2) 3,000 Hz at 70 db; (3) cold; and (4) touch. Intense stimuli evoked observable responses consistently.

Behavioral inhibition as a response to auditory stimuli in the neonate was reported by Birns, Blank, Bridger, and Escalona (1965). They recognized the importance of soothing auditory stimuli, such as music, humming of a motor, or the human voice, on the behavior of an infant. A mother will often report that she can quiet her infant with music or the "tone of her voice." Birns et al. (1965) did not select these stimuli for their study because of the complexity and nature of the sounds; instead they used a series of tones. Four observers judged the infant's behavior on a rating scale designed to describe the infant's state. A 75 percent agreement was found on an average, showing that auditory stimulation can produce a soothing effect on human neonates. A low tone of 150 cps had the most soothing effect, a higher tone of 500 cps was of intermediate effectiveness, and an intermittent low tone of 150 cps was least effective. Changes in the total activity levels of the infant were observed with cessation of crying.

In recent years, investigators dealing with infant response patterns have found the videotape recorder to be invaluable. Responses can be recorded, repeated, and observed

at a later time. League and Bzoch (1968, 1970) videotape recorded mother-infant sequences of 16 infants ranging in age from shortly after birth to 15 months of age. Initial fixation of attention by infants was measured by their arrest of body movements in response to adult voices and an infant's voice. A stopwatch was used to record the length of time of arrested activity in seconds. A pattern of difference in response time for the various voice qualities was noted. The response time differed for angry voices as compared to friendly voices and according to the sex of the speaker. Responses were no different between male and female infants. The developmental attention of infants upon five differing voice conditions increased in fixation as the infant grew.

The importance of a mother's speech in eliciting a response in a single 4-month-old baby during a game of peekaboo was shown by Greenfield (1972). Kagan (1972) concluded that infants older than 8 or 9 months can think. His conclusions were based on videotaped experiments which measured attention to visual and auditory stimuli in which infants showed an ability to resolve discrepancies between stimuli and solve problems.

Condon and Sanders (1974) observed that 1- to 2-day-old neonates can perform "precise and sustained movements that are synchronous with the articulated structure of adult speech." Their findings offer a new approach to the study of language acquisition and imply that infants rehearse the

linguistic patterns of their culture through rhythmic body movements long before they speak.

The work currently undertaken at the Infant Development Laboratory in the Harry A. Waisman Center on Mental Retardation and Human Development at the University of Wisconsin in Madison, Wisconsin, under the direction of Lewis A. Leavitt, and Philip A. Morse, appears in their first Research Status Report, August, 1975. This report includes their studies of auditory/speech perception in infants and their research methodology. They have been and are now presently involved in the cardiac activity patterns associated with exploration of the young infant's orienting response to speech discrimination.

CHAPTER III

METHOD

Introduction

A review of the current literature brought out the following major concepts which led to the development of the methods of procedure followed in this study.

Human voice, speech, and language patterns are of critical importance for the satisfactory acquisition of language in human infants (Markel, 1969; League and Bzoch, 1970; Schiefelbush and Lloyd, 1974). Lennenberg (1967) theorized that the development of language is biologically predetermined. Examination of infant behavior has shown that infants have an innate ability to respond adaptively to their environment (Friedlander, 1970; Eimas et al., 1971) and that newborns do respond to auditory stimuli (Eisenberg, 1970).

It is, of course, difficult to determine the actual effect of voice, of speech, and of non-human sounds on the development of linguistic capabilities of very young infants (Moffitt, 1971). Since infants are unreliable informants and since the auditory stimuli used in studies to date have been widely varient, accepted methods for measuring infant responses, therefore, have often relied on physiological

response measurements combined with behavioral assessment (Koch, 1968a, b).

Several recent studies have utilized the ECG to investigate infant responses to auditory stimuli. Changes in heart rate following auditory stimuli have been considered a reliable physiological record of infant responses to sound (Lipton et al., 1965; Graham et al., 1968). The nature of alterations in heart rate produced by auditory stimuli has been studied by Bartoshuk (1962). The duration of the heart rate response to auditory stimuli in infancy appears to be widely variable between subjects (Zeigler, 1951). Further, the physiologic state of the infant (i.e., crying, sleeping, alert) at the time of testing appears to be an important experimental variable (Lewis, Kagan, Campbell, and Kalafut, 1966; Lewis and Spaulding, 1967; Lewis, Dodd, and Harwitz, 1969; Berg, Berg, and Graham, 1971).

A variety of auditory stimuli at different intensity levels have been previously used in heart rate experiments for adults and infants: for example, white noise (Steinschneider et al., 1966), tones of 1,000 Hz at varying intensities of 50, 70, and 90 dB (Germana and Klein, 1968), synthetic consonant speech sounds (Eimas et al., 1971; Moffitt, 1969), mothers and female voices (Turnure, 1971; Friedlander, 1970), and tape-recorded inflected speech samples (League and Bzoch, 1968, 1970).

Because of the wide variability in changes of heart rate and in other physiological measures of responses to

auditory stimuli, behavioral observational studies continue to present an important alternate means of evaluating infant responses to auditory stimuli. For example, Bridger (1961) found that changes in heart rate were correlated with activity levels. Observer judgments of infant behavioral responses to sound have been used to provide information about affective discriminative capabilities in infants and young children (Bergman and Escalona, 1959; Birns et al., 1965; Lamper and Eisdorfer, 1971). Infants differ, however, in temperament, activity levels, and sensitivity thresholds. Therefore, just as changes in heart rate may be affected by inner-organ functions, so may observable behavior responses. It is not clear from the existing literature whether physiological or behavioral response measures are more appropriate or valid for investigations of infants under 2 months of age.

Even the quality of voice and intonation patterns of the speaker may present another important parameter in studies dealing with auditory responses of infants. These paralinguistic factors are viewed as very important early message carriers of meaning and are thought to have a critical bearing on language acquisition (Markel, 1969; League and Bzoch, 1970; Banikiotes, Banikiotes, and Montgomery, 1972; Markel, Bein, and Phillis, 1973).

Purpose

The general purpose of the study was to determine whether very young infants already respond differently to speech than

to non-speech sounds as measured by changes in heart rate and/or behavior. Included in this general purpose were the following additional questions: (1) Do infants held on their mother's lap respond differently from those not held? (2) Do male infants respond differently from female infants? (3) Do the responses of infants to male voices differ from their responses to female voices? (4) Finally, do infants generally show differing responses to each of the 12 auditory stimuli?

Hypothesis

The major hypothesis of this study was that infants of 4, 5, and 6 weeks of age will already respond differently to human than to non-human auditory stimuli as evidenced by changes in heart rate and behavior. The null hypothesis, therefore, is stated as follows: Infants of 4, 5, and 6 weeks of age will not display responses to human auditory stimuli that are different from those displayed to non-human auditory stimuli, as evidenced by either heart rate change or behavior.

Subjects

Twenty-three normal Caucasian infants were the subjects of this study. Table 1 shows the age of all subjects included in the investigation. Examination of Table 1 shows that the mean age of the total sample was 33.0 days (or 5 weeks). It can be further seen that the mean age for the

TABLE 1

Sex and Age of Subjects

Males	Age (days)	Females	Age (days)
1.	27	1.	29
2.	29	2.	30
3.	29	3.	32
4.	29	4.	33
5.	30	5.	33
6.	31	6.	35
7.	31	7.	36
8.	31	8.	36
9.	32	9.	36
10.	33	10.	37
11.	35		
12.	36		
13.	38		
Mean Age - 31.6		Mean Age - 33.7	

Note: The mean age for male and females is 32.5.

13 male subjects was 31.6, closely approximating the mean age of the 10 female subjects, 33.7 days (also the fifth week). The ages ranged from 27 days to 38 days, and the majority of the infants (i.e., 16) were 5 weeks old. The age in days was based on the following distribution: 1 week (0-7); 2 weeks (8-14); 3 weeks (15-21); 4 weeks (22-28); 5 weeks (29-35); 6 weeks (36-42).

Subjects for the study were obtained in the following manner. The names of parents of potential infant subjects

were first obtained from a nurse instructor of a local Lamaze Childbirth Preparation class. A parent, usually the mother, was contacted by telephone. The nature and purpose of the study was explained. Parents were reassured that all safety precautions would be taken in their infant's behalf. Most parents wanted to participate and to observe their infant's responses to the experiment.

The experimental procedure was scheduled at a time convenient for the parents, usually midmorning. Each child was first tested while held in his mother's arms. Ample time was allowed for rest, feeding, and changing of the infant between the first and second phases of each study. Each infant had been examined previously by a pediatrician and had been found healthy and without abnormalities.

On the day of the experiment, the procedure to be followed was again reviewed and parents signed a consent form (Appendix B) allowing their infants to participate in the study.

Auditory Stimuli

The controlled auditory stimuli used were first recorded on a Sony (Model TC105A) tape recorder, using a 1/4-inch Scotch (#202) recording tape at a speed of 3 3/4 inches per second. Five-second segments of the following 12 auditory stimuli were recorded.

Human Voice (recorded live):

1. Sustained production of the vowel "ah" or /a/ by a male voice.

2. Sustained production of the vowel "ee" or /i/ by a male voice.

3. Sustained production of the vowel "ah" or /a/ by a female voice.

4. Sustained production of the vowel "ee" or /i/ by a female voice.

Human Speech (from a previous experimental tape recording of Bzoch and Williams made in 1972):

1. An angry male voice saying the words, "stop that," repeated.

2. A friendly male voice saying the words, "stop that," repeated.

3. An angry female voice saying the words, "stop that," repeated.

4. A friendly female voice saying the words, "stop that," repeated.

Non-human Sound:

1. A baby beeper variable tone of 1,000 Hz used as a screening test for hearing in newborns.

2. A pure tone from an audiometer at 1,000 Hz.

3. A segment of music, kettle drums from the musical background of Richard III, used to suggest a heavy, forceful quality like that of an "angry" voice.

4. A segment of music from a music box used to suggest a light quality like that of a "friendly" voice.

The measured sound pressure level as well as the subjective perception of loudness by two judges of each segment listed above were carefully equalized on each of four master tapes using a sound-pressure-level meter to a loudness level of (approximately) 65 dB. Since the auditory stimuli included human voice, speech samples, tones, and music, equal

loudness among these varying types of complex sounds could be only closely approximated. However, the investigator believed that through the procedure followed the factor of loudness matching of each segment had been satisfactorally controlled for the purposes of this study.

Four master tapes were prepared so that the order of the auditory stimuli were different on each. This was done in order to control any effect that order of presentation might have. A table of random numbers (ITT, 1972) was used to randomize the order of the auditory stimuli on the four tapes (see Table 2).

TABLE 2

Auditory Stimuli Tape Segment-
Chart of Random Order

	Auditory Stimuli	Tape I Order	Tape II Order	Tape III Order	Tape IV Order
1.	Angry Male	11	6	8	3
2.	Friendly Male	10	4	5	5
3.	Angry Female	3	5	2	10
4.	Friendly Female	12	3	9	2
5.	Baby Beeper	7	12	6	11
6.	Pure Tone	9	7	1	1
7.	Light Music	6	8	7	7
8.	Heavy Music	2	11	10	4
9.	Male (ah)	1	10	4	12
10.	Male (ee)	8	9	3	9
11.	Female (ah)	4	1	11	6
12.	Female (ee)	5	2	12	8

The master tapes were prepared in the following manner. A 30-second segment of silent tape was spliced between each

5-second segment of auditory stimuli, and at the beginning and end of each tape. The four different orders of stimuli presented in Table 2 were followed. Four different master tapes (and a copy of each) were prepared.

In order to establish further control for the loudness level received by the infants, a sound leader tape of non-recorder visible plastic was placed at the beginning of each tape. This was followed by a recorded tone of 400 Hz to be used to set a standard sound pressure level of 70 dB (using a Sound Level meter (GR1565-A)) before the collection of data on each subject proceded. This procedure was followed in order to be sure that the subjects all received the stimuli at the same loudness level throughout the experiment.

The auditory stimuli tapes were presented free-field on a two-channel Wollensak Stereo tape recorder (Model 5720) with loudness held constant. On one channel the auditory stimuli were recorded for presentation. The other channel was prepared to play a 180 Hz tone beginning 10 seconds after each auditory stimulus and ending 10 seconds before the next auditory stimulus. This was done to synchronize and standardize the ECG recording. This tone was used to trigger a small cue light to go <u>on</u> and was not heard. The cue light indicated to the operator of the electrocardio-recorder to stop recording for that stimulus interval and take up tape. Conversely, when the cue light went off, this signaled that electrocardiographic recording was to begin

10 seconds prior to the next stimulus presentation (see Appendix A).

Recording of ECG Data

The heart rate responses were recorded on an Avionic (Model #425) Electrocardiorecorder with an on-and-off switch and color coded electrodes. The electrocardiorecorder was used to make a permanent record of each infant's heart rate on magnetic tape. The portable ECG device used was battery operated. This device was selected for use in this experiment for safety purposes. The nurse supervisor in charge of the ECG unit placed the electrodes on the infants and operated the electrocardiorecorder. Electrodes were placed in the following positions: white, just medial to the left shoulder; green, lower right costal margin; red, fourth intercostal space at the sternal border (V-1 position).

With the electrodes in place and after an adjustment period, the recorder was turned on for 60 seconds to obtain a baseline tracing of each infant's heart rate before the first stimulus was presented. After the recorder was turned off, the tape was taken up by hand to separate the baseline electrocardiogram from subsequent tracings. The electrocardiorecorder was turned on 10 seconds before each sound stimulus. The signal for this was the cue light activated by the second channel on the tape recorder. The electrocardiorecorder recorded electrical complexes from the heart 10 seconds before the sound stimulus, during the 5-second

stimulus, and for 10 seconds after the sound stimulus. The electrocardiorecorder was then turned off and more tape was taken up by hand to separate heart rate recordings (Appendix A). The same procedure was followed for each of the 12 auditory stimuli on each sound tape.

At the completion of each experiment, the tape from the electrocardiorecorder was rewound to the beginning and placed on an Avionics Dynamic Electrocardioscanner (Model #660). The scanner was tuned to the trend position. The 15 cardiac cycles during each 25-second period of recording were thereby averaged by the machine to determine the average cycles per minute.

The tape was then rewound and cardiac cycles were projected on an oscilloscope, and a permanent electrocardiogram was simultaneously made on heat-sensitive paper. The heart rate was also measured from the permanent electrocardiogram, thus providing a double check of the heart rate per minute by use of both the trended heart rate and the actual rate from the electrocardiogram.

Videotape Data Recording

Each infant's responses were videotape recorded with a Fairchild TC-175 television camera fitted with a Cannon zoom lens and placed on a Samson (Model Quick Set, Inc.) stand, 10 feet from the infant. A permanent videotape recording was made on a sony AV-3600 recorder using a 1/2-inch helical scan tape with a Sony F-95 microphone attached. Filming

was monitored on a Setchell-Carlson 2100 video monitor. Frontal lighting was used for better definition of facial expressions and to eliminate shadows.

A large faced clock was placed in the camera field to give a permanent record of time. Afixed to the clock stand was a display of the date, subject number, and stimulus tape order presented.

Later, an Odetic timer (digital serial time apparatus) was used to display time sequence down to tenths of a second on each film. When the videotape of each infant was completed the digital serial time system was overlaid at the bottom by a copying process. A clear permanent record of subject number, tape segment, and display in minutes, seconds, and tenths of seconds was thus obtained. A copy was made of each video tape (Appendix A).

Testing Procedure

Each infant was tested first while held on the mother's lap and then alone in an infant car seat placed on the floor. The study was conducted in a well-lit, carpeted, acoustically treated interior room of 12 feet by 24 feet. All testing equipment except for the television camera was behind a screen and not visible to the infant.

Infant in lap procedure. The mother was seated with her infant in her lap in a chair at a 45 degree angle to the camera. The video picture was regulated to include the infant and the mother's head. After the electrocardiorecorder

electrodes were attached to the infant, a period of adjustment to the surroundings was allowed before starting the experimental procedure.

The mother was instructed to keep the infant in the camera's view and was told that she would hear sounds during the testing procedure. If she felt her infant needed comforting, she should do so, but she was told to try to remain as still and quiet as possible while doing this.

When the infant and mother were comfortable and a baseline heart rate recording had been made, one of the 7-minute auditory stimulus tapes was selected and played. The infant's behavioral responses were filmed by the videotape apparatus and heart rate was recorded by the procedure described.

Infant in carseat procedure. Because of the young age of the subjects a rest period of 10 to 20 minutes was allowed between the two experimental procedures on each infant. The infant was then placed in an infant carseat for the second experimental procedure (Love Seat, General Motors) and this was set on the floor. The mother sat near the infant but not in his line of vision. If the infant required comforting the mother was allowed to do so, but was urged to avoid blocking the camera's view or picking up the infant.

When the infant appeared comfortable, the next auditory stimulus tape in sequence was played and the infant's responses were recorded as before. The first experiment in which the

infant was on his mother's lap was termed held and the second in the infant seat was called not held. The time required to prepare each infant and perform the held and not held experiments was about half an hour, including the rest period (Appendix A).

An observer recorded the state over time of each infant during each experiment. The state of the infant was described as either (1) crying, (2) awake, (3) drowsy, (4) sleeping, or (5) other. The term mixed was used to describe an infant with a variable state of attention throughout an experiment. The recording form (Appendix B) included a column for averaged heart rate during each stimulus for later statistical purposes.

Analysis of Data

Both the ECG and videotape data collected in the above procedure were analyzed for the purpose of this investigation. The data collected from the videotape were analyzed separately.

ECG analysis. To test for differences in heart rate response between the held and not-held positions, the difference between the heart rate in each position was taken for all 12 stimuli and tested by the single F test. This is equivalent to running a t-test for each of the 12 stimuli (Morrison, 1967).

Heart rate responses were also analyzed to determine whether a significantly different change was produced by

different human voice, human speech, and non-human sound stimuli. A randomized block design was used in each case since each infant was subject to each stimulus. The F test that was performed in each case is equivalent to the ANOVA for a randomized block design in which one tests for any differences among responses to the four human voice, four human speech, and four non-human sound stimuli.

Videotape analysis. Three judges, who had each had previous experience in observing infant responses to sound, independently viewed and recorded their judgments of each infant's apparent response to each stimulus. They both viewed and listened to the playback of the experiment to make their judgments. Changes in behavior that were looked for included cessation of activity, increased activity (for example, increase in, or cessation of, sucking), or facial expressions (smile, mouth movements, frowns, startle, eye movements, etc.). A definite observable change in behavior following an auditory stimulus was recorded as "Yes" and judged as apparent. A probable change in behavior was also recorded as "Yes" and marked as possible. A lack of any observable response was recorded as "No." If the infant was crying or asleep during a sound stimulus, a check was made in the "Infant Unable to Respond" column on the recording form. Neither "Yes" nor "No" judgments resulted under this condition. Also, if defects in videotaping occurred for any segment, a check was placed in the "Film

Not Clear" column and no "Yes" or "No" judgment was attempted (Appendix B).

Statistical Analysis of Observer Judgments

The majority response (i.e., at least two out of three identical judgments) recorded by the three judges was used as the final data set for calculations of each infant's responses to sound stimuli. A test of interobserver reliability of these data was first computed by the value of a statistic kappa, which is essentially the percentage of agreement between pairs of judges, adjusted for the agreement expected due to chance alone. The statistic takes the value unity when the judges always agree, zero when the agreement is exactly the percentage predicted by chance, and positive or negative values according to whether agreement exceeds or falls short of that predicted by chance (Light, 1971).

An analysis was then made of any differences found for the total experimental sample between the held and the not held conditions. A sign test was used to determine whether this factor influenced the degree of infant response.

A further analysis was run to determine whether there was an interaction between the sex of the infant and the sex of the speaker. This was accomplished by comparing the proportions of "Yes" responses to male and to female human speech stimuli and comparing these data for male and the

female subjects. The Fisher's Exact Test for 2 x 2 tables was used (Fisher, 1973).

Finally, an analysis was made to determine whether infants showed a preference for human voice and speech stimuli versus non-human sound stimuli. The sign test was used for this purpose. The same method was applied to all pairwise comparisons between stimuli.

CHAPTER IV

RESULTS

The findings are presented below, first, in terms of the analysis made by videotape observations, second, by electrocardiography analysis, and third, by a summary of major findings.

Videotape Observations

The first step in the analysis of the videotape observation judgmental data was to determine the degree of interjudge reliability. To determine the degree of agreement among the three observers scoring videotaped infant responses the interobserver reliability was computed by the value of a statistic kappa (Light, 1971) and produced a K of 0.60. The significance of this value was assessed as compared to zero (percentage predicted by chance) using the standard error 0.12. A z-score of 5.00 was obtained, which is highly significant. Thus, there was a high level of reliability achieved in the observer data. All subsequent analyses, therefore, were based on consensus judgments (majority opinions), and the investigator felt justified in considering these data to be both valid and reliable indices of infant responses to auditory stimuli. The next step in the

analysis was to determine if any significant differences occurred when the infants were in the held or in the not held conditions.

In comparing the overall proportions of "Yes" responses for the held and not held positions for each infant, six infants had a greater proportion of "Yes" responses in the held position, 11 had a greater proportion when not held, and 5 were ties. These findings were not significant ($p > .3$) using the sign test. Thus, responses were not significantly affected by whether the infant was held or not held.

The interaction between the sex of the infant and the sex of the speaker of the human voice stimuli was examined with the Fisher Exact Test for 2 x 2 tables (Table 3).

TABLE 3

Interaction Between Sex of Infants and Sex of Preferred Voice

Sex of Subject	Sex of Preferred Voice Male	Female	Total
Male	3	2	5
Female	2	3	5
Total	5	5	10

Table 3 includes data showing only the number of subjects, by sex, who showed a more frequent response to male or to female voice stimuli. It can be seen from Table 3 that 3 of the 13 male subjects responded more frequently to male voice stimuli and 2 more frequently to female voices. The

remaining 8 responded equally to both types of stimuli. Conversely, 2 of the 10 female subjects appeared to prefer (respond to) male speakers and 3 to female speakers. The results are not significant, indicating a lack of preference for either male or female voices by infants of either sex.

Next, it was desired to get an overall indication of the possible preference of the infants for human voice as against non-human stimuli. Table 4 shows the number of subjects who responded more frequently to human voice, to non-human stimuli, or equally to both. It can be seen from Table 4 that 14 infants showed a greater proportion of positive responses to human voice stimuli, 4 to non-human sound stimuli, and 5 were tied.

TABLE 4

Number of Subjects Showing a Preference to Human or to Non-Human Stimuli

	Preference for Human Voice Stimuli	Preference for Non-Human Stimuli	No Preference
No. of Subjects	14	4	5

The sign test was used to assess the significance of the differences found. The findings represent a significant statistical difference ($p < .05$), indicating preference for human voice stimuli.

The same statistical method, the sign test, was applied for making all pairwise comparisons between stimuli. The results of this analysis appear in Table 5.

TABLE 5

Partial Ranking of Stimuli Based on Pairwise Comparisons at the 5 Percent Level

3	1	2,4,6,7,9,10,11	5,8	12

Note: No pair of stimuli underscored by the same line is to be declared significantly different.

The stimuli (Table 5) are partially ranked according to the number of infants showing a preference on a pairwise basis. There were only a few significant comparisons at the .05 level. For example, stimulus 12 (angry female) produced a response significantly more often than did either stimulus 1 (light music) or stimulus 3 (baby beeper). Stimulus 5 (male "ah") and stimulus 8 (angry male), produced the next ranked proportions of positive responses. This rank order of positive responses may suggest that the human voice is a practical tool for use in gaining auditory attention from an infant in free-field hearing testing of infants.

Making all possible pairwise comparisons introduces an important element for possible error. Even if there are no

real statistical differences, if many comparisons are made, chance alone will lead to a few observed significant differences. For further information, a key to the stimulus codes and a rank order of each stimuli are shown in Table 6.

TABLE 6

Stimulus Codes and Overall Proportions of Positive Response $\hat{p}$ (ignoring "checks")

Number	Stimulus	$\hat{p}$	Rank Order
1	Light music	.795	11
2	Pure tone	.805	10
3	Baby beeper	.791	12
4	Heavy music	.881	6
5	Male AH	.953	2
6	Male EE	.930	4
7	Friendly male	.857	7
8	Angry male	.951	3
9	Female EE	.854	8
10	Female AH	.900	5
11	Friendly female	.829	9
12	Angry female	.976	1

Heart Rate Change Data

The ECG data for each 25-second test interval were recorded on a table in the order of presentation for each subject under each condition. The changes in heart rate, whether decreases or increases, were those calculated for each stimulus period from the previous or baseline rate.

Twenty-two infants had electrocardiographic recordings satisfactory enough for analysis. The single F test, equivalent to running a t-test for each of the 12 stimuli,

showed no significant difference in heart rate response to all stimuli regardless of whether the infant was held or not held.

To determine whether heart rate response was affected differently by human voice sounds, human speech, and non-human sound stimuli, a randomized block design was used in each case because each infant was subject to each stimulus. The F test, equivalent to the ANOVA for a randomized block design, showed a lack of significant difference in each instance. Table 7 shows the mean and standard deviations of average heart rate for all subjects on each stimuli. It can be seen that wide standard deviations existed across all stimuli indicating wide variation in individual heart rate measures for all subjects. Thus, none of the stimuli had a significant effect on the infant's heart rate.

A major difficulty in the heart rate response experiments was that infants were in different attentive states. Infants might fall asleep or cry, some wanted to be nursed, while some were distracted or began hiccuping. These factors influenced the heart rate regardless of other variables. The number of infants that remained alert and quiet throughout the experiment were too few to sample to arrive at statistically significant results.

Summary of Results

The major hypothesis of this study, that infants respond preferentially to human rather than non-human auditory

TABLE 7

Infant Study ECG Data

	Baseline Heart Rate	Female (ah)	Male (ee)	Angry Female	Female (ee)	Light Music
Held						
Mean	106.0	101.6	106.1	113.8	111.9	105.1
SD	30.9	40.0	40.3	34.1	30.9	34.5
Not held						
Mean	109.3	108.5	108.0	106.6	112.1	107.2
SD	31.3	28.1	34.3	26.4	22.1	30.5

TABLE 7: Extended

Male (ah)	Pure Tone	Friendly Male	Angry Male	Heavy Music	Friendly Female	Baby Beeper
108.6	111.4	104.6	104.5	109.5	113.6	107.2
31.7	30.0	36.4	37.8	35.3	32.6	29.4
111.0	111.2	104.8	109.3	110.6	109.9	109.8
30.7	29.0	27.1	31.1	33.3	25.6	25.0

stimuli, is supported by the behavioral data recorded from the videotape study. It appears that the heart rate data is too variable at this age range to indicate any significant trends in auditory responses to these stimuli.

Four-, five-, and six-week-old infants statistically appear to show a significantly greater number of behavioral responses to human as opposed to non-human auditory stimuli. Whether infants are held or not held does not effect these responses. Male and female infants respond alike, with neither sex showing a preference for tape recorded auditory stimuli of either male or female voices.

Infants of both sexes responded significantly more often to the angry female voice than to baby beeper or the light music. Further, all infants responded significantly more frequently to the angry male and the male "ah" stimuli than to the baby beeper. The rank order of frequency of responses to specific stimuli shows a trend in that five of the most frequent six responses out of 12 stimuli used were to human voice.

The heart rate was not significantly altered by any of the experimental parameters that influenced the behavioral responses of the infants. The varying basal attention state of the infants may have affected these heart rate results.

CHAPTER V

DISCUSSION

This experimental study examined changes in behavior and heart rate to different auditory stimuli in infants of 4, 5, and 6 weeks of age. Infants of this age were selected to determine whether changes in behavior or heart rate to auditory stimuli would occur this early in life. League and Bzoch (1968, 1970) in their longitudinal study of infants from birth to 15 months of age found evidence of early infant response to the human voice. The intent of this study was to ascertain whether these infants would show preferential behavioral and heart rate changes to human speech sounds over non-human sounds. The major finding was that infants of this age do respond preferentially to the human voice rather than to non-human sounds. The findings supported Lennenberg's (1967) theory that language is biologically predetermined for human beings.

The very young age of the infants makes the experimental procedure interesting and challenging. Infants are non-verbal and their state of attention is variable. Rapid alterations in motor activity and bodily functions occur which present many problems for data collection. The effects of sounds on behavior and heart rate were selected to provide different responses that could be compared.

The scoring by judges of videotaped recordings of behavioral effects gave statistically significant and reliable results. This study showed that data collection of behavioral responses for this age subject using videotape is an acceptable method for providing a permanent record that could be repeatedly viewed. A suggested improvement in videotaping infant responses would be to take a closeup view of the infant during the test procedures rather than including the mother in the picture since whether the infant was held or not held by the mother produced no statistically significant difference in infant behavioral responses. Furthermore, if a color cue could be superimposed on the video picture before the beginning of the 5-second stimulus segment this might provide a visual aid to the judges indicating that the stimulus is about to begin. This color cue might be used in addition to the auditory stimulus which the judges are listening to as the videotape is being played. The present method as reported, however, was found to be valid and reliable.

The procedure for recording electrocardiograms on infants of this age presented many problems. The electrocardiographic monitoring was not a difficult procedure but the question which arose was important. Was the change in heart rate that was being measured a result of the sound stimuli or was it the result of cries, hiccuping, body movements, sucking on a nipple, or any other number of bodily

states? The varying attentive states of the infants and the wide variability of heart rate from infant to infant in the resting state does not make it possible to definitively answer this question.

The infants showed no statistically significant changes in heart rate in response to the auditory stimuli used in this study. This is most likely due to the immaturity or lack of adequate development of the autonomic nervous system at this age rather than to a lack of affective responses by the infants. That responses do occur to the auditory stimuli used was shown by the behavioral observation data.

Infants of 4, 5, and 6 weeks of age in this study did not show significant changes in heart rate in response to the auditory stimuli, but older infants with a more mature autonomic nervous system might. An electrocardiographic monitoring system has been designed which provides a beat-by-beat continuous determination of heart rate (Motorola AN-714). A battery operated instrument such as this would give a more accurate display of beat-by-beat data for use with infants. Also, if the investigator were to use heart rate measurements again in future research such as this, an attempt would be made to record the heart beats from 1 or 2 seconds prior to the introduction of a stimulus, during the stimulus, and for 10 seconds post-stimulus, rather than for a duration of 10 seconds pre-stimulus, as had been designed for this study. The attempt to obtain an average heart

rate by including a baseline reading may dampen the results of the heart rate for the presenting sound stimulus. Nevertheless, electrocardiography as a physiological measurement of heart rate response should be considered a potential method for use with older infants when the heart rate has begun to stabilize until proven otherwise.

The major findings of this investigation indicate the need for further research dealing with the perception and response of infants to auditory stimuli as a means of better understanding how language is acquired. It may be that as early as two weeks of age the infant is able to selectively attend to intonation patterns and qualities of the human voice. Not only the humaness of the sound, but also the voice quality and intonation of the speaker have been found to be important in the type of response elicited. Different voice qualities produce different affective responses (Costanzo, Markel, and Costanzo, 1969) and voice quality imparts information about the speaker's personality (Markel, 1969).

Further research should be designed to present fewer auditory stimuli at one listening period. Testing infants from birth to 6 months of age might show when a preferential discrimination is made between voice qualities and among varying patterns of voice intonation. Of the 12 stimuli used in the study, a greater behavioral response was elicited by 5 of the 8 human sounds and by 1 of the 4 non-human sounds.

In future research, instead of presenting 12 stimuli, only 2 could be used in an experiment to more clearly delineate responses between sounds.

The results of this study support the theory of biologic predisposition to language among humans. Infants become familiar with the human voice and respond differentially to human sounds even before these sounds convey word meaning. Further investigation is needed to determine at what age infants begin to demonstrate a preference, if any, for male or female voices. The research suggested would add valuable knowledge to the field of psycholinguistics and improve our understanding of the psychological implications of the human voice in personality development.

The preferential response of infants to human voice sounds implies a biological basis for this preference, and further suggests that language acquisition is facilitated by hearing other humans speak. If this is true, it has application to clinical pediatric audiology. Human voice stimuli in place of the baby beeper could be used to test infant hearing shortly after birth. A standardized tape recording of human voices could be used in free field audiometry to test the hearing of infants.

In conclusion, an increased understanding of speech perception by infants can lead to a better appreciation of the method of language acquisition by infants.

Summary

The major hypothesis that infants respond to the human voice in preference to non-human sounds is supported by the results of this study. Twenty-three normal Caucasian infants, 4, 5, and 6 weeks of age, were studied for changes in behavioral and heart rate in response to auditory stimuli. The stimuli included male and female voices, human speech samples, and non-human sounds of pure tones and music. Videotape and electrocardiographic recordings were made of each infant during the presentation of the 12 tape recorded sound stimuli. Each sound stimulus was presented for 5 seconds followed by a 30-second period of silence.

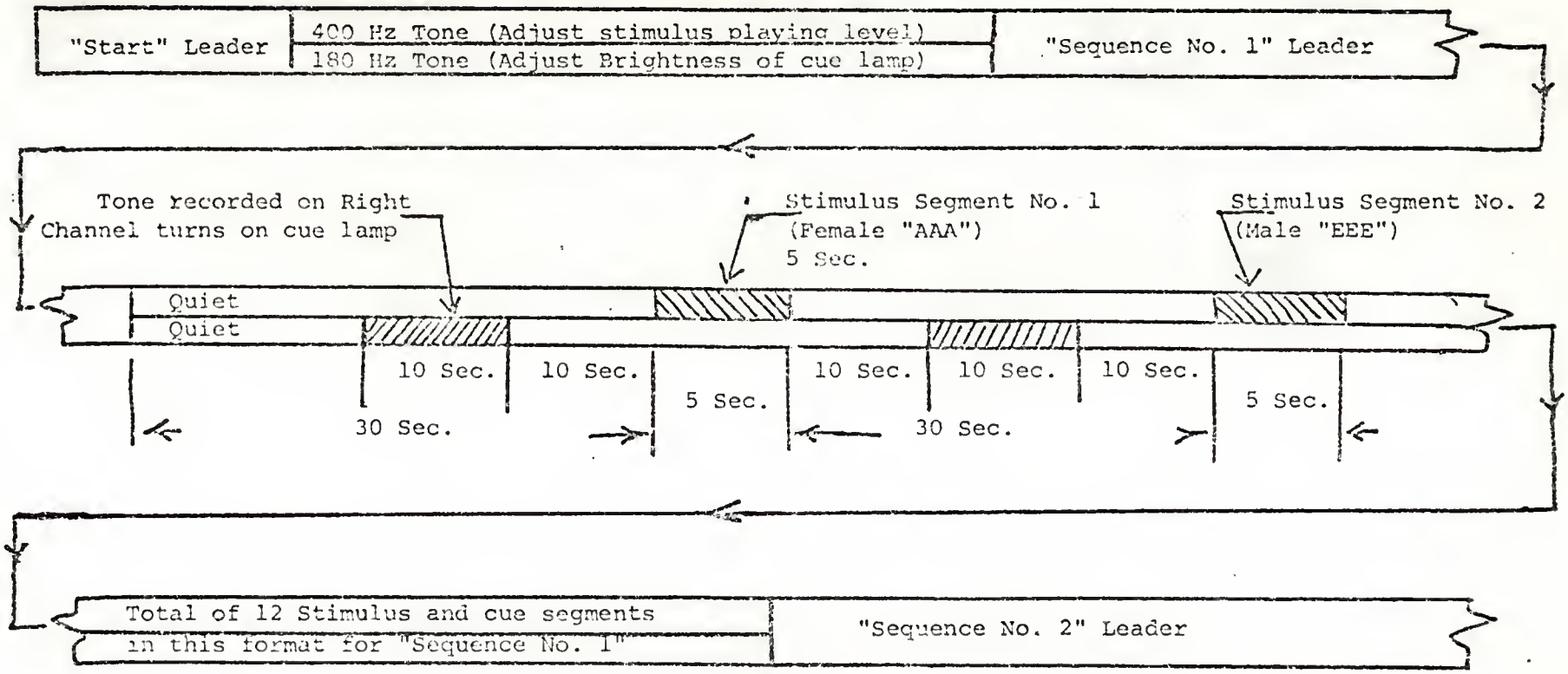
The findings of this study are that 4-, 5-, and 6-week-old infants show no significantly different response in behavior to auditory stimuli whether held or not held by their mothers, and responded significantly more often to human than to non-human sounds. Neither male nor female infants showed a preference for voices of the same or opposite sex. Statistically, a significantly greater number of behavioral responses were elicited by the angry female, angry male, and male "ah" stimuli.

Although behavioral changes were noted in response to the stimuli, no significant alteration in heart rate was observed. The variability of heart rate in infancy and the behavioral state of the infant may be factors that dampen or obscure changes in heart rate in response to auditory stimuli.

The observation that infants react preferentially to human as compared to non-human sounds supports the hypothesis that infants are biologically predisposed to speech.

APPENDIX A

Stimulus Tapes



Notes:

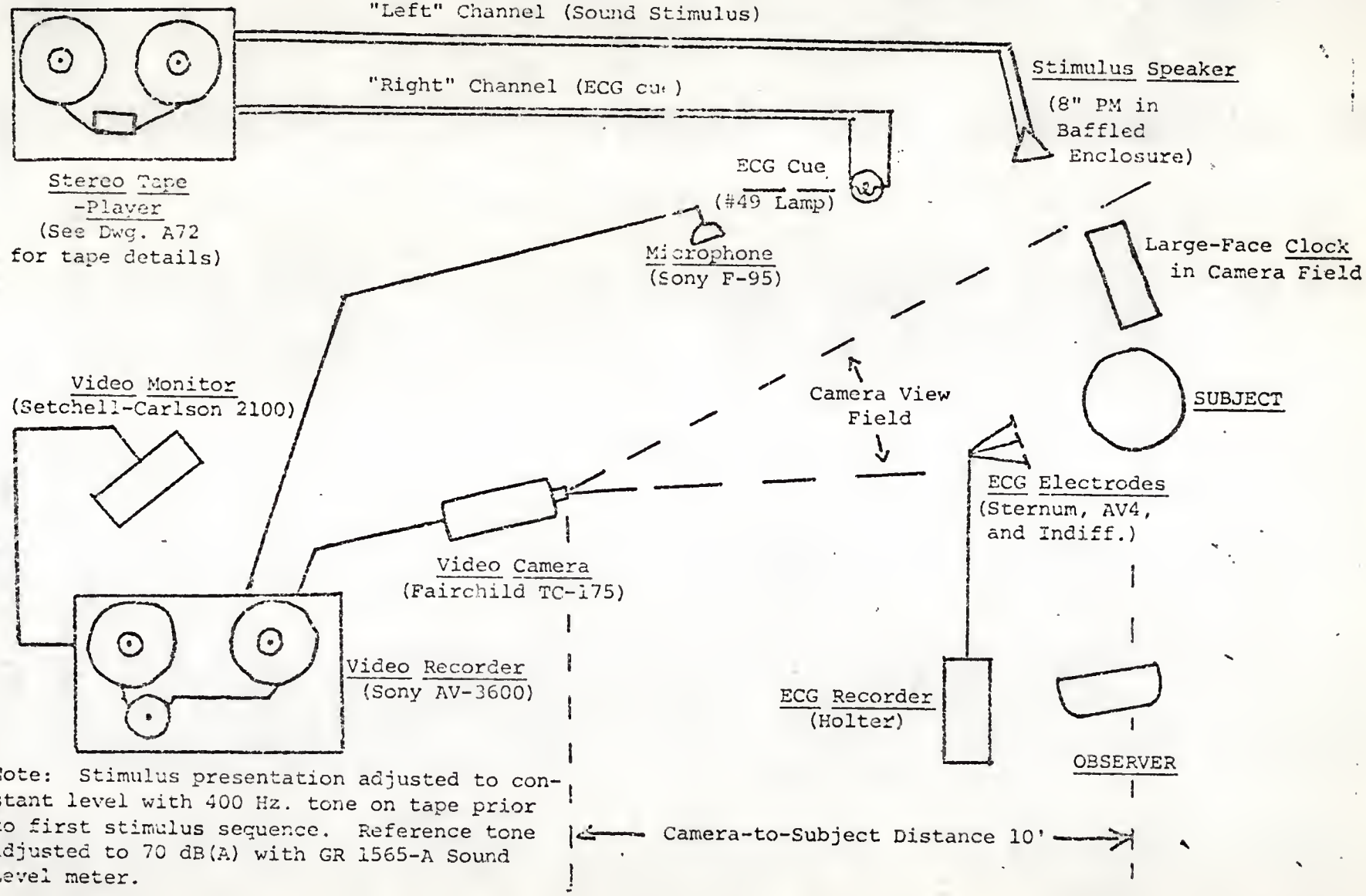
See tabulation of content of each of 12 segments in each of 4 sequences.

Leader sections are non-recording, visible plastic tape.

Stimulus Tape Number by Subject

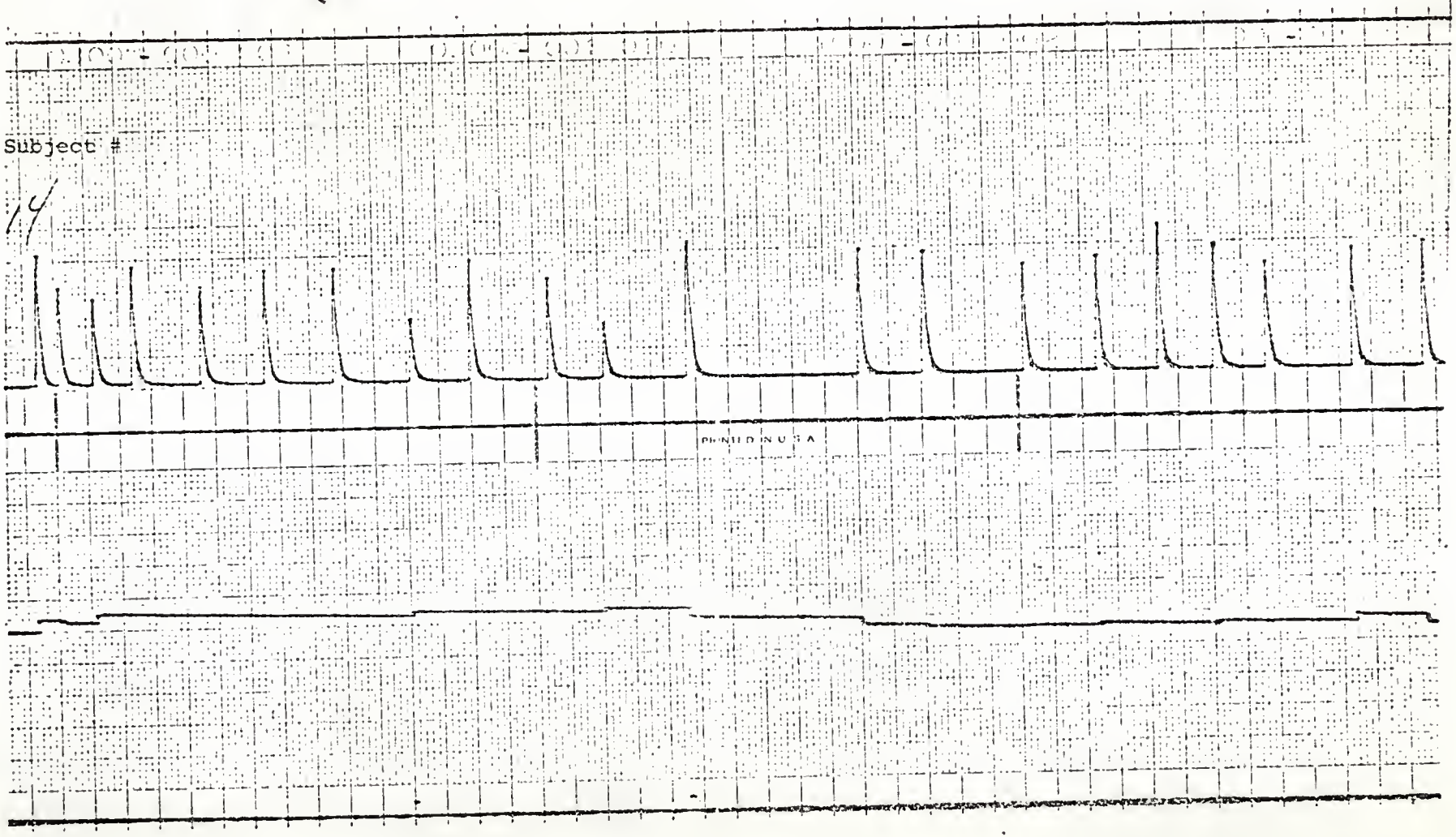
Subject:	Tapes:	Subject:	Tapes:
No. 2	(I, II)	No. 15	(I, III)
3	(I, III)	16	(II, III)
4	(II, III)	18	(I, IV)
5	(II, IV)	19	(II, I)
6	(I, IV)	20	(III, I)
7	(II, I)	21	(III, II)
8	(III, I)	22	(III, IV)
9	(III, II)	23	(IV, I)
10	(III, IV)	24	(IV, II)
11	(IV, I)	25	(IV, III)
12	(IV, II)		
13	(IV, III)		
14	(I, II)		

Experimental Setting



Note: Stimulus presentation adjusted to constant level with 400 Hz. tone on tape prior to first stimulus sequence. Reference tone adjusted to 70 dB(A) with GR 1565-A Sound Level meter.

Sample Heart Rate Trend During Experimental Procedure for Twelve Auditory Stimuli



APPENDIX B

University of Florida
Dissertation Study of Emergent Language Development
Consent Form

1. In order to learn how your baby begins to understand what you say and how to speak, we would like to obtain TV films of you and your baby while you are listening to sounds. We are interested in how your infant responds to the things he or she hears. While you are being filmed, you will be seated with your baby on your lap. A nurse will assist to record the baby's heart rate; (this is done by taking a heart tracing, called electrocardiography) as you listen to sounds and human voices played on a tape recorder. There is nothing in this study that will be of any danger to your child. The time for making the video film to record this information is approximately six minutes. The procedure will be repeated with the infant listening alone in an infant seat. These TV films and recordings will be studied and compared with responses of other infants who are participating in this study. The information obtained will help us better understand the importance of the infant's interest in sounds in the environment.

2. I have read and understand the above described procedure in which I am to participate with my infant. I consent to have my child, _____, birthdate_____, participate in this dissertation study accepting full responsibility, and the information used for research, teaching and publication purposes.

3. Signed_____

Dated_____

Witnesses_____

_____

ECG Data Form

Subject_____ Name_____

Date_____ Birthdate_____ Parents_____

Address_____ Phone_____

Tape I

Stimulus Order	Heart Rate Time	Comments
1-11 - Female (ah)		
2-10 - Male (ee)		
3-3 - Angry female		
4-12 - Female (ee)		
5-7 - Pleasant music		
6-9 - Male (ah)		
7-6 - Pure tone		
8-2 - Friendly male		
9-1 - Angry male		
10-8 - Unpleasant music		
11-4 - Friendly female		
12-5 - Baby beeper		

ECG Data Form

Subject_____ Name_____

Date_____ Birthdate_____ Parents_____

Address_____ Phone_____

Tape II

Stimulus Order	Heart Rate Time	Comments
1-6 - Pure tone		
2-4 - Friendly female		
3-5 - Baby beeper		
4-3 - Angry female		
5-12 - Female (ee)		
6-7 - Pleasant music		
7-8 - Unpleasant music		
8-11 - Female (ah)		
9-10 - Male (ee)		
10-9 - Male (ah)		
11-1 - Angry male		
12-2 - Friendly male		

ECG Data Form

Subject_____ Name_____

Date_____ Birthdate_____ Parents_____

Address_____ Phone_____

Tape III

Stimulus Order	Heart Rate Time	Comments
1-8 - Unpleasant music		
2-5 - Baby beeper		
3-2 - Friendly male		
4-9 - Male (ah)		
5-6 - Pure tone		
6-1 - Angry male		
7-7 - Pleasant music		
8-10 - Male (ee)		
9-4 - Friendly female		
10-3 - Angry female		
11-11 - Female (ah)		
12-12 - Female (ee)		

ECG Data Form

Subject_____ Name_____

Date_____ Birthdate_____ Parents_____

Address_____ Phone_____

The scoring by judges of videotaped recordings of behavioral effects gave statistically significant and reliable results. This study showed that data collection of behavioral responses for this age subject using videotape is an acceptable method for providing a permanent record that could be repeatedly viewed. A suggested improvement in videotaping infant responses would be to take a closeup view of the infant during the test procedures rather than including the mother in the picture since whether the infant was held or not held by the mother produced no statistically significant difference in infant behavioral responses. Furthermore, if a color cue could be superimposed on the video picture before the beginning of the 5-second stimulus segment this might provide a visual aid to the judges indicating that the stimulus is about to begin. This color cue might be used in addition to the auditory stimulus which the judges are listening to as the videotape is being played. The present method as reported, however, was found to be valid and reliable.

The procedure for recording electrocardiograms on infants of this age presented many problems. The electrocardiographic monitoring was not a difficult procedure but

Videotape Infant Response Scoring Sheet

Tape 1

Subject # _____

Held _____ Not Held _____

Stimulus Order	Yes		No	Infant Unable to Respond	Film Not Clear
	Apparent	Possible			
1-11 - Female (ah)					
2-10 - Male (ee)					
3-3 - Angry female					
4-12 - Female (ee)					
5-7 - Light music					
6-9 - Male (ah)					
7-6 - Pure tone					
8-2 - Friendly male					
9-1 - Angry male					
10-8 - Heavy music					
11-4 - Friendly female					
12-5 - Baby beeper					

Infant Response Scoring Sheet

Tape II

Subject # _____

Held _____ Not Held _____

Stimulus Order	Yes: Apparent	Yes: Possible	No	Infant Unable to Respond	Film Not Clear
1-6 - Pure tone					
2-4 - Friendly female					
3-5 - Baby beeper					
4-3 - Angry female					
5-12 - Female (ee)					
6-7 - Light music					
7-8 - Heavy music					
8-11 - Female (ah)					
9-10 - Male (ee)					
10-9 - Male (ah)					
11-1 - Angry male					
12-2 - Friendly male					

Infant Response Scoring Sheet

Tape III

Subject # _____

Held _____ Not Held _____

Stimulus Order	Yes: Apparent	Yes: Possible	No	Infant Unable to Respond	Film Not Clear
1-8 - Heavy music					
2-5 - Baby beeper					
3-2 - Friendly male					
4-9 - Male (ah)					
5-6 - Pure tone					
6-1 - Angry male					
7-7 - Light music					
8-10 - Male (ee)					
9-4 - Friendly female					
10-3 - Angry female					
11-11- Female (ah)					
12-12- Female (ee)					

Infant Response Scoring Sheet

Tape IV

Subject # _____

Held _____ Not Held _____

Stimulus Order	Yes Apparent	Yes Possible	No	Infant Unable to Respond	Film Not Clear
1-3 - Angry female					
2-5 - Baby beeper					
3-10 - Male (ee)					
4-2 - Friendly male					
5-11 - Female (ah)					
6-1 - Angry male					
7-7 - Light music					
8-4 - Friendly female					
9-12 - Female (ee)					
10-9 - Male (ah)					
11-6 - Pure tone					
12-8 - Heavy music					

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BIOGRAPHICAL SKETCH

Constance Caranasos was born on July 22, 1934, in Milwaukee, Wisconsin, the daughter of Nicholas James Demeter, M. D., and Ella Trahadias Demeter. After completion of public school education in Milwaukee she entered Wisconsin State College in Milwaukee where she majored in Exceptional Education/Speech Correction, and minored in Psychology. She received Key membership in Sigma Alpha Eta, national speech and hearing honorary society in 1954. Upon receiving her Bachelor of Science degree in 1955, she moved to Columbus, Georgia, and established the first program of Speech Correction Services for the Muscogee County School System. In 1956 she founded and became director of Speech Therapy for the Cerebral Palsy Center in Muscogee County, Columbus, Georgia. Clinical Certification in the American Speech and Hearing Association under the sponsorship of Dr. Stanley Ainsworth, University of Georgia was obtained in 1957. She organized the first Chapter of the Council for Exceptional Children in Columbus, Georgia in 1958 and in 1959 she was awarded an Elks Foundation Scholarship to Boston University. In 1960 she established the first Speech Therapy Service at the Sunland Training Center, the State Institution for Mentally Retarded in Gainesville, Florida. From 1962 to 1964 she was a Speech and Language Therapist in the Department of Communicative Disorders, College of Health Related Professions at the University of Florida. An honorary

membership was given to her by the Alpha Delta Chapter of Sigma Alpha Eta at the University of Florida in 1963. She became a member of the Florida Speech and Hearing association and the Florida Cleft Palate Association.

After moving to Washington, D. C., in 1964 she became Speech Pathologist and clinical supervisor of Speech Pathology students doing clinical practicum experience at the Children's Hospital Speech Center. Upon receiving an Office of Education Fellowship she returned to the University of Wisconsin in Milwaukee from 1966 to 1967 for graduate study and received a Master of Science degree. In 1967 she founded and became Director of the Milwaukee Children's Hospital's first Speech Clinic. Further, she established the first liaison for training of graduate students in clinical Speech Pathology at the University of Wisconsin in Milwaukee with the Milwaukee Children's Hospital. She held a joint appointment with the University of Wisconsin as Communication Specialist, Speech Pathology. With active support from the Pilot Club of Milwaukee, the Speech Center became a project of this professional women's service club. She participated as Speech Pathologist for the Cleft Palate Team of Milwaukee Children's Hospital and conducted research with Sidney K. Wynn, M. D., and Ralph Leutenegger, Ph.D., which resulted in the publication of an article entitled <u>Speech Status of Post-Adolescents Following Bone Flap Palatal Surgery</u>. She presented a paper, "An Interdisciplinary

Approach to Evaluation of Communication Disorders," and chaired a panel discussion on the Interdisciplinary Team Approach using Diagnostic Speech Therapy at the 1968 Wisconsin Speech and Hearing Association Convention. As Director of the Speech Center at Milwaukee Children's Hospital she participated actively in providing information to the public regarding the services of this program. She became a member of the American Cleft Palate Association in 1968. In 1969 she was invited to return to the University of Florida as Speech and Language Therapist and Clinical Instructor in the Department of Communicative Disorders, College of Health Related Professions. In 1970 she presented a paper on Diagnostic Speech Therapy to the Learning Problems Conference for Pediatricians and Teachers directed by Dr. John Ross, pediatric neurologist, conducted at the Medical Center of the University of Florida. She entered the Graduate School at the University of Florida, to begin work toward the degree of Doctor of Philosophy. Her major study has been Speech Pathology in the Department of Speech, College of Arts and Sciences.

She is married to George J. Caranasos, M. D., and has a daughter, Ellen Constance Caranasos.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Vernon D. VanDeRiet
Associate Professor of
Clinical Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Kenneth R. Bzoch, Chairman
Professor of Speech

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Norman N. Markel
Professor of Speech

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

G. Paul Moore
Professor of Speech

This dissertation was submitted to the Graduate Faculty of the Department of Speech in the College of Arts and Sciences and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

March, 1976

Dean, Graduate School

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